USE OF COAL DRYING TO REDUCE WATER CONSUMED IN PULVERIZED COAL POWER PLANTS

QUARTERLY REPORT FOR THE PERIOD
April 1, 2005 to June 30, 2005

by

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Report Issued June 2005

DOE Award Number DE-FC26-03NT41729

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ABSTRACT

This is the tenth Quarterly Report for this project. The background and technical justification for the project are described, including potential benefits of reducing fuel moisture using power plant waste heat, prior to firing the coal in a pulverized coal boiler.

During this last Quarter, analyses were initiated to determine the impacts of coal drying on cost of energy, and results from these analyses will be described in the next Quarterly Report.

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INTRODUCTION

Background

Low rank fuels such as subbituminous coals and lignites contain significant amounts of moisture compared to higher rank coals. Typically, the moisture content of subbituminous coals ranges from 15 to 30 percent, while that for lignites is between 25 and 40 percent, where both are expressed on a wet coal basis.

High fuel moisture has several adverse impacts on the operation of a pulverized coal generating unit. High fuel moisture results in fuel handling problems, and it affects heat rate, mass rate (tonnage) of emissions, and the consumption of water needed for evaporative cooling.

This project deals with lignite and subbituminous coal-fired pulverized coal power plants, which are cooled by evaporative cooling towers. In particular, the project involves use of power plant waste heat to partially dry the coal before it is fed to the pulverizers. Done in a proper way, coal drying will reduce cooling tower makeup water requirements and also provide heat rate and emissions benefits.

The technology addressed in this project makes use of the hot circulating cooling water leaving the condenser to heat the air used for drying the coal (Figure 1). The temperature of the circulating water leaving the condenser is usually about 49°C (120°F), and this can be used to produce an air stream at approximately 43°C (110°F). Figure 2 shows a variation of this approach, in which coal drying would be accomplished by both warm air, passing through the dryer, and a flow of hot circulating cooling water, passing through a heat exchanger located in the dryer. Higher temperature drying can be accomplished if hot flue gas from the boiler or extracted steam from the turbine cycle is used to supplement the thermal energy obtained from the circulating cooling water. Various options such as these are being examined in this investigation.

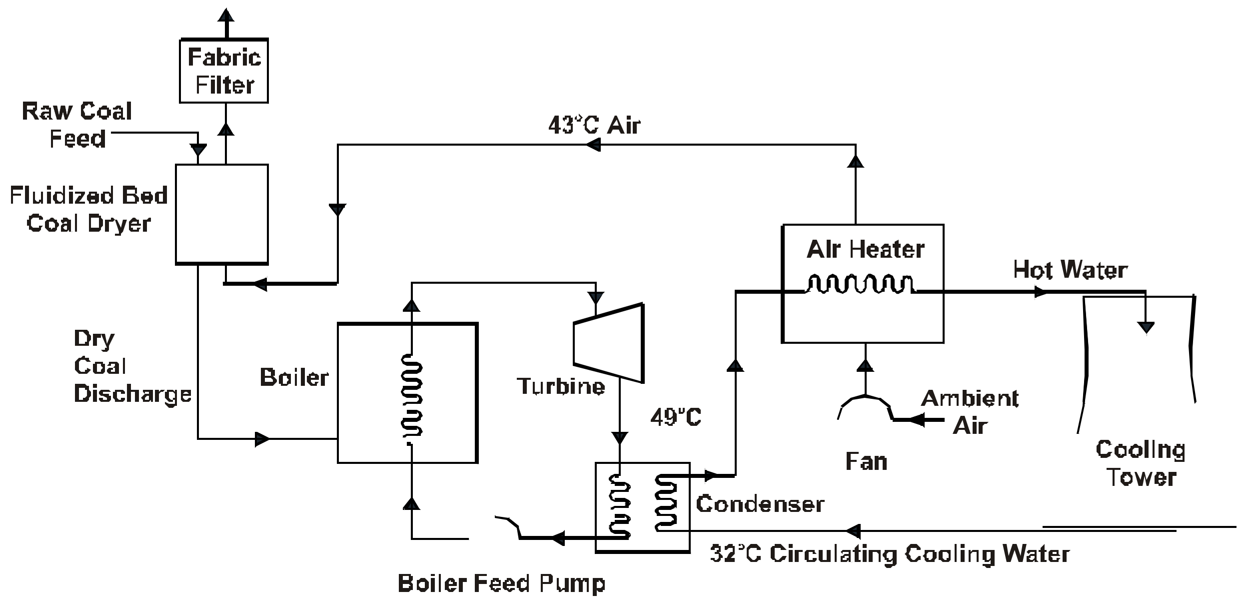

Figure 1: Schematic of Plant Layout, Showing Air Heater and Coal Dryer (Version 1)

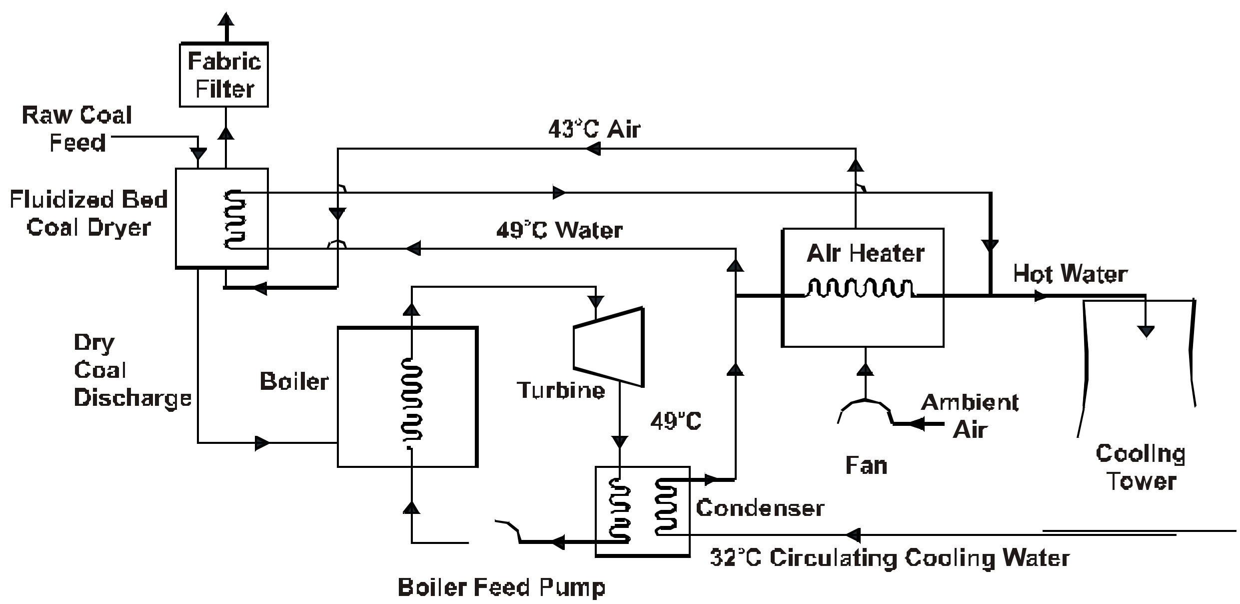

Figure 2: Schematic of Plant Layout, Showing Air Heater and Coal Dryer (Version 2)

Previous Work

Two of the investigators (Levy and Sarunac) have been involved in work with the Great River Energy Corporation on a study of low temperature drying at the Coal Creek Generating Station in Underwood, North Dakota. Coal Creek has two units with total gross generation exceeding 1,100 MW. The units fire a lignite fuel containing approximately 40 percent moisture and 12 percent ash. Both units at Coal Creek are equipped with low NO_x firing systems and have wet scrubbers and evaporative cooling towers.

A coal test burn was conducted at Coal Creek Unit 2 in October 2001 to determine the effect on unit operations. The lignite was dried for this test by an outdoor stockpile coal drying system. On average, the coal moisture was reduced by 6.1 percent, from 37.5 to 31.4 percent. Analysis of boiler efficiency and net unit heat rate showed that with coal drying, the improvement in boiler efficiency was approximately 2.6 percent, and the improvement in net unit heat rate was 2.7 to 2.8 percent. These results are in close agreement with theoretical predictions (Figure 3). The test data also showed the fuel flow rate was reduced by 10.8 percent and the flue gas flow rate was reduced by 4 percent. The combination of lower coal flow rate and better grindability combined to reduce mill power consumption by approximately 17 percent. Fan power was reduced by 3.8 percent due to lower air and flue gas flow rates. The average reduction in total auxiliary power was approximately 3.8 percent (Ref. 1).

This Investigation

Theoretical analyses and coal test burns performed at a lignite fired power plant show that by reducing the fuel moisture, it is indeed possible to improve boiler performance and unit heat rate, reduce emissions and reduce water consumption by the evaporative cooling tower. The economic viability of the approach and the actual impact of the drying system on water consumption, unit heat rate and stack emissions will depend critically on the design and operating conditions of the drying system.

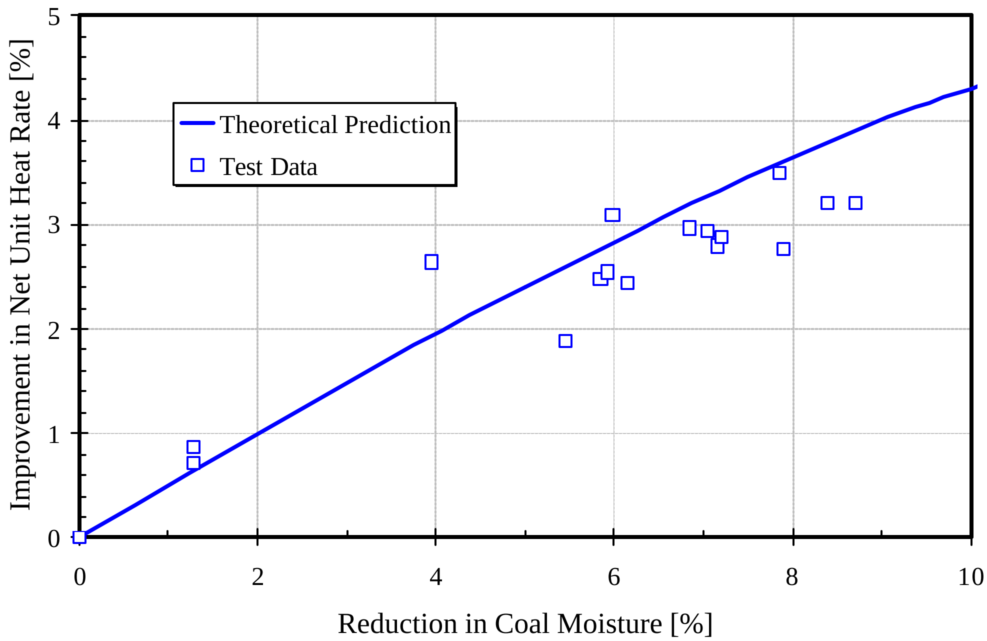

Figure 3: Improvement in Net Unit Heat Rate Versus Reduction in Coal Moisture Content

The present project is evaluating low temperature drying of lignite and Power River Basin (PRB) coal. Drying studies are being performed to gather data and develop models on drying kinetics. In addition, analyses are being carried out to determine the relative costs and performance impacts (in terms of heat rate, cooling tower water consumption and emissions) of the various drying options, along with the development of an optimized system design and recommended operating conditions.

The project is being carried out in five tasks. The original Task Statements included experiments and analyses for both fluidized bed and fixed bed dryers (see previous Quarterly Reports). After the project was started, it became clear there is no advantage to using fixed bed dryers for this application. For this reason, the technical scope was changed in June 2004 to emphasize fluidized bed drying. The Task Statements in this report reflect this change in emphasis.

Task 1: Fabricate and Instrument Equipment

A laboratory scale batch fluidized bed drying system will be designed, fabricated and instrumented in this task. **(Task Complete)**

Task 2: Perform Drying Experiments

The experiments will be carried out while varying superficial air velocity, inlet air temperature and specific humidity, particle size distribution, bed depth, and in-bed heater heat flux. Experiments will be performed with both lignite and PRB coals. **(Task Complete)**

Task 3: Develop Drying Models and Compare to Experimental Data

In this task, the laboratory drying data will be compared to equilibrium and kinetic models to develop models suitable for evaluating tradeoffs between dryer designs. **(Task Complete)**

Task 4: Drying System Design

Using the kinetic data and models from Tasks 2 and 3, dryers will be designed for lignite and PRB coal-fired power plants. Designs will be developed to dry the coal by various amounts. Auxiliary equipment such as fans, water to air heat exchangers, dust collection system and coal crushers will be sized, and installed capital costs and operating costs will be estimated**. (Task Complete)**

Task 5: Analysis of Impacts on Unit Performance and Cost of Energy

Analyses will be performed to estimate the effects of dryer operation on cooling tower makeup water, unit heat rate, auxiliary power, and stack emissions. The cost of energy will be estimated as a function of the reduction in coal moisture content. Cost comparisons will be made between dryer operating conditions (for example, drying temperature and superficial air velocity). **(Task in Progress)**

EXECUTIVE SUMMARY

Background

Low rank fuels such as subbituminous coals and lignites contain relatively large amounts of moisture compared to higher rank coals. High fuel moisture results in fuel handling problems, and it affects station service power, heat rate, and stack gas emissions.

This project deals with lignite and subbituminous coal-fired pulverized coal power plants, which are cooled by evaporative cooling towers. The project involves use of the hot circulating cooling water leaving the condenser to provide heat needed to partially dry the coal before it is fed to the pulverizers.

Recently completed theoretical analyses and coal test burns performed at a lignite-fired power plant showed that by reducing the fuel moisture, it is possible to reduce water consumption by evaporative cooling towers, improve boiler performance and unit heat rate, and reduce emissions. The economic viability of the approach and the actual impact of the drying system on water consumption, unit heat rate and stack emissions will depend critically on the design and operating conditions of the drying system.

This project is evaluating alternatives for the low temperature drying of lignite and Power River Basin (PRB) coal. Laboratory drying studies are being performed to gather data and develop models on drying kinetics. In addition, analyses are being carried out to determine the relative costs and performance impacts (in terms of heat rate, cooling tower water consumption and emissions) of drying, along with the development of an optimized system design and recommended operating conditions.

Results

The last Quarterly Report described relative power plant performance impacts of using power plant waste heat to dry lignite and PRB coals and potential water savings due to the reduction in cooling tower makeup water requirements. Analyses are in progress to determine the impacts of coal drying on cost of energy, and results from these analyses will be described in the next Quarterly Report.

ANALYSIS OF IMPACTS ON UNIT PERFORMANCE AND COST OF ENERGY

The last Quarterly Report described power plant performance impacts of using power plant waste heat to dry lignite and PRB coals and potential water savings due to the reduction in cooling tower makeup water requirements. The financial aspects of coal drying include drying equipment capital costs, additional operating and maintenance costs, fuel savings due to improved heat rate, income or savings from emissions credits due to reduced stack emissions and financial benefits of reduced water consumption. Analyses are in progress to determine the costs and benefits of drying, and results from these analyses will be described in the next Quarterly Report.

CONCLUSIONS

Analyses are in progress to determine the costs and benefits of coal drying on cost of energy, and results from these analyses will be described in the next Quarterly Report.

PLANS FOR NEXT QUARTER

The Task 5 analyses on impacts of coal drying on cost of energy will continue and cost comparisons will be made between various drying system configurations and operating conditions.

REFERENCE

1. Bullinger, C., M. Ness, N. Sarunac, E. K. Levy, "Coal Drying Improves Performance and Reduces Emissions," Presented at the 27th International Technical Conference on Coal Utilization and Fuel Systems, Clearwater, Florida, March 4-7, 2002.